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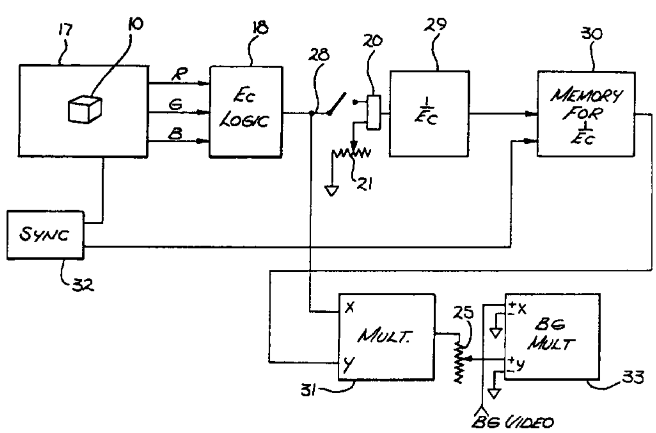
(54) Backing color and luminance non-uniformity compensation for linear image compositing

(57) Control signal E_c is generated (18) proportional to luminance of a foreground scene comprising a subject (10) selectively before a blue backing (17). E_c is corrected for luminance non-uniformity (Fig. 3) by multiplying (31) live E_c with the subject present by the reciprocal (29) of stored (30) E_c without the subject such that the corrected control signal (LE_c) is unity wherever the foreground video signal represents the backing (17). Color correction (Fig. 6) corrects, for example, the blue video signal to a predetermined ideal value (36) where the foreground signal represents the backing (17) and may be applied to all three of the RGB signals using one (Fig. 7), two (Fig. 8A) or three (Fig. 8) memories.

FIG. 3



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Description

BACKGROUND

Electronic image compositing is employed by the video industry for superimposing (compositing) a foreground (FG) subject over a background (BG) scene. The FG subject is typically a person or an object placed before an illuminated colored backing. The compositing apparatus replaces the colored backing with the BG scene. This process is used extensively in producing TV shows and commercials.

For nearly 30 years a switching process known as chroma key has been used for compositing video images. Switching occurs between the BG scene and the FG subject as a function of the presence or absence of the chroma of the backing.

A switching compositing system which switches as a function of the presence or absence of the chroma of the backing represents an "exclusive OR" logic; that is, one sees either the FG scene "OR" the BG scene but not both. When a subject is semitransparent, such as thin smoke, liquids and glassware, one should see the subject, and one should also see the background scene through the subject. For semitransparent subjects, there is no appropriate place to switch. A switching compositing System is incapable of reproducing semitransparent subjects. More recently the applicant has introduced to the video industry a linear, non-switching, image compositing method utilizing an "AND" concept. Apparatus which utilize this process are sold under the trademark Ultimatte. In this method a linear control signal (E_c) is formed as a function of the brightness and visibility of the colored backing. Any color may be used from the backing, but blue has been most popular, and therefore the colored backing is often referred to as the Blue Backing. The backing will therefore be referred to as a blue backing in the description of this invention.

The linear control signal E_c is normally used to reduce the chroma and luminance of the backing to a low level such as neutral grey or to zero video (black). E_c also linearly controls the level of the BG scene video. The BG scene is thus visible through the FG subject to the extent the subject was transparent. Since the colored backing may be reduced to black, the BG scene may be added to the FG subject by simple addition. The linear compositing method is described by the applicant's following U.S. patents: US-A-3,595,987; US-A-4,007,487; US-A-4,100,569; US-A-4,344,085; US-A-4,409,611; US-A-4,569,013; US-A-4,625,231. The linear (non-switching) compositing method produces superb and undetectable composite images. Smoke, liquids, glassware and fine detail, such as individual strands of hair, are composited as if the scene were real. Shadows are retained and become shadows on the BG scene. Unfortunately, the linear compositing method also reproduces every wrinkle in the backing, its texture, its seams, smudges, rub marks and unintentional shadows.

On large colored backings it is not a simple matter to achieve uniform illumination. Large backings require multiple light sources whose patterns imperfectly overlap. The light sources must be kept out of the camera field thus placing them in positions not conducive for achieving illumination uniformity. Limitations of available electric power, or an insufficient number of lighting units, typically results in lower levels of illumination to be compensated for by opening the camera lens aperture a stop or two. Even if the backing illumination were uniformed, a large aperture setting on the camera lens induces some lens vignetting (corner fall off).

For a variety of reasons the colored backing is not likely to provide a uniform video signal level over the entire field. Since E_c is derived from this colored field and controls the level of the BG scene, unless E_c is corrected, the background scene will contain all of the brightness variations occurring on the colored backing and induced by lens vignetting.

A clean, smooth, seamless backing having uniform luminance is sometimes achieved, but this ideal is not always practical, nor economically feasible. In the applicant's later patents, methods and apparatuses are disclosed for correcting backing defects, non-uniform illumination, and undesired shadows by electronic means. For example, an adjustable E_c clip level causes the backing to appear to be uniformly illuminated. A second circuit called "cleanup" helps to remove backing seams as well as dusty footprints tracked onto a clean blue floor. When used for small corrections, the E_c clip and cleanup do not produce an observable penalty.

The penalty for using substantial amounts of E_c clipping is that the subject appears to be backlighted. This backlighting effect causes a slight glow to loose hair and to subject edges. While a backlight effect may sometimes be desirable, in other scenes it is not acceptable.

The penalty for using excessive cleanup is the loss of fine edge detail, such as individual strands of hair. The loss of edge detail is quite essential in eliminating the fine wires used to lift objects or persons off a floor so as to make it appear that they are flying. However, when cleanup is used to eliminate footprints or backing defects, loss of hair detail becomes an unwelcome tradeoff.

The preceding discussion dealt with luminance non-uniformity of the backing. A second type of non-uniformity is color. One part of the backing will appear to have a slightly different shade of blue, for example. Although one may use the identical material in coloring a wall and floor, the wall will always have a higher color saturation than the floor. Visually, and to the camera, a wall appears to be a bright blue, while a floor appears to be a bluetinted grey. The camera faces the wall surface at essentially right angles, but the floor is seen at a small low angle. Diffuse surfaces provide low angle scattering of white light and thus the floor appears to be a somewhat desaturated blue.

When one subtracts a sufficient level of the E_c control signal from FG video to cause the blue wall to go black, the floor remains a dull grey. Additional subtraction of the control signal to reduce the floor to black will cause the wall to approach black too soon causing a darkened edge to FG subjects in the wall area.

Applicant's U.S. patent US-A-4,625,231 compensates for the wall/floor color difference by using an automatic bias circuit. This circuit continuously monitors the video in the blue backing area and adjusts the E_c control signal level on a line-by-line basis to result in video just reaching zero in both the wall and floor areas.

This method of correcting for color variation works well for wall and floor color differences, but it does not adequately correct for color differences that occur for blue set pieces. A styrofoam rock, a flat, a stairway or other shape is painted blue and placed on the stage to match the size, shape and apparent position of similar objects in the BG scene. Such blue set pieces add realism to the composite scene, since the actor's shadow is distorted by the rock or staircase, as it would have been had he been in the actual BG scene. Set pieces also permit the actor to appear to walk behind objects that are actually in the BG scene.

These blue set pieces may be placed at various angles and positions with respect to the camera and set lighting lamps. The result is a slight color difference. An autobias circuit cannot adequately correct for color and brightness differences on individual set pieces.

SUMMARY OF INVENTION

It is an aim of this invention to electronically eliminate the non-uniformity of color or luminance of the blue backing and of blue set pieces employed in image compositing, without incurring the penalties of edge glow, edge darkening, loss of edge detail and other anomalies.

Within a given scene, there are no criteria in the FG video signal by which one may electronically differentiate between floor glare which is not wanted, and a thin layer of white fog which is wanted; between color differences in the backing, which are not wanted and color differences in the FG scene which are wanted; and between a shadow cast by a blue set piece which is not wanted, and a shadow cast by the actor which is wanted.

Criteria exist when the FG video signal is examined with subject removed and compared with the FG video signal obtained with subject in place.

According to the present invention there is provided an apparatus as set forth in claim 1, claim 8, claim 11 or claim 12 appended hereto.

Also, according to the present invention there is provided a method as set forth in claim 5 or claim 13 appended hereto.

Each method and apparatus allows for RGB color correction signals based on the video signal without the subject, i.e. when the subject is absent, or at least for all areas of the backing which are not covered by the subject throughout the sequence.

While the correction of backing color non-uniformity is a primary benefit to a linear compositing system, the switching type compositing systems may also benefit as a result of improved switching criteria provided by a uniform backing. The present invention may also be utilized with cameras which provide a fourth channel generally known as luminance (59% Green, 30% Red, 11% Blue) in addition to the three RGB channels. The only change necessary to practice the invention with such cameras is the addition of circuitry identical to that which is used for each of the RGB channels.

BRIEF DESCRIPTION OF THE DRAWINCS

Fig. 1 is a block diagram showing a video compositing system which may utilize the present invention;

Fig. 2 is a schematic diagram showing a circuit for implementing E_c logic 18;

Fig. 3 is a block diagram of a circuit for implementing backing luminance correction;

Fig. 4 is a block diagram of a circuit for loading a memory used to correct backing color non-uniformities with the foreground subject present;

Fig. 5 is a schematic drawing of a circuit for implementing the subtraction of a percentage of E_c for a single color video signal;

Fig. 6 is a block diagram of a circuit for implementing backing color correction for a single color;

Fig. 7 is a block diagram of a circuit for implementing backing color correction for three color video signals using a single memory;

Fig. 8 is a block diagram of a circuit for implementing backing color correction for three color video signals using three memories;

Fig. 8a is a block diagram of a circuit for implementing backing color correction for three color video signals using two memories;

Fig. 9 is a block diagram of a clip circuit for setting a threshold below which RGB video representing the subject is inhibited.

DETAILED DESCRIPTION OF THE INVENTION

The methods and apparatus described herein utilize the deviation of the backing luminance and color from some ideal uniform value and correct for such non-uniformity without disturbing or distorting the image quality of an FG subject. Non-uniformity correction can be achieved by comparing the video obtained with the subject in front of the blue backing with the video obtained from the blue backing alone. There are several ways of making and utilizing this comparison.

The E_c Correction Method

A control signal is developed from the criteria present in the colored backing, namely that when Blue is high and Red and Green are low, the camera is examining a picture element consisting of the blue backing. However, when either red or green is high, or blue is low, then the camera must be examining a nonblue subject. An equation or logic as simple as $E_c = B - (G \text{ OR } R)$, where OR signifies "the larger of", will provide a control signal E_c that is linearly proportional to the luminance and visibility of the backing, being 1.0 in the blue backing area, zero in the nonblue subject area, and somewhere between zero and 1.0 in semitransparent subject areas. A preferred control signal is implemented by the circuit drawing of Fig. 2. The circuit of Fig. 2 and its various elements are fully explained in applicants prior patent, US-A-4,344,085, see Fig. 2 and the discussion in columns 3 - 8.

Figure 1 illustrates the additions of correction circuits shown if Figures 3 and 6 to a prior art video compositing system of the type described in US-A-4,625,231 for correcting an E_c control signal for backings having non-uniform luminance and color.

An apparatus to achieve compensation for non-uniform luminance of the backing by correction of the E_c control signal is shown in Fig. 3.

Its function is as follows: The blue backing 17 is scanned before a subject 10 is put in place. E_c logic 18 provides a control signal proportional to the luminance and visibility of the blue backing.

Linear OR gate 20 limits the lowest value of E_c to a voltage set by control 21. This OR gate prevents reciprocal circuit 29 from dividing by zero when E_c goes to zero at the end of each scanline. Typically, control 21 will be set to some practical limit such as 0.5 of peak E_c. Closure of switch 28 provides E_c through OR gate 20 to reciprocal circuit 29, to store $1/E_c$ in memory 30. Switch 28 is then released and subject 10 is put in place. With switch 28 open, E_c is connected only to the X input of multiplier 31. The corrections stored in memory 30 are connected to the Y input of multiplier 31. The output of multiplier 31 is the product of the live E_c at a given point in the scene, and the stored value of an E_c reciprocal at that point. A sync signal created by sync generator 32 provides synchronization between the scanning beam of the video camera and the reading and writing of memory 30.

In any area occupied by an opaque subject 10, live E_c will be zero. The fact that it is being multiplied by a factor of a little above or below unity, does not change the value of zero. The output of multiplier 31 is therefore a corrected E_c (LE_c) which is now unity for the entire backing, and zero for the FG subject area. This is what E_c would have been without correction if the backing has been illuminated with perfect uniformity. The output of multiplier 31 is connected (through level control 25) to the Y input of multiplier 33 which is the customary control point for the BG video in a linear composition system. In a non-linear compositing systems such as ones using the chromakey switching technique, the output of multiplier 31 is the corrected keying (switching) signal that switches between the FG and BG scenes. In this connection, a control signal identifying the presence or absence of the blue backing is referred to as the key signal.

The circuit of Figure 3 may be implemented with the following electronic components: E_c logic 18 may be implemented according to the circuit shown in Figure 2. (See, U.S. Patent No. US-A-4,344,085.) Switch 28 may be any commercially available switch such as a toggle switch. Controls 21 and 25 are commercially available potentiometers. Reciprocal circuit 29 may be implemented as a multiplier having an input connected to switch 28 and a second input connected to a source of 1 volt wherein the multiplier is connected as a divider. (See Motorola "Linear Circuits" Handbook.) This multiplier as well as multipliers 31 and 33 are commercially available components, for example, the Motorola 1495 and 1595 four quadrant multipliers. Sync generator 32 is also commercially available such as Tektronix Model SPC 170A NTSC sync generator. Memory 30 may be any memory capable of storing a video signal, such as magnetic tape. Appropriate video recorders and play back units are well known to those skilled in the art. Alternatively, memory

30 may be implemented as a digital random access memory, in which case analog to digital and digital to analog converters would be needed to convert the analog video signal to a digital signal for storage in memory 30 and then back to analog form for input to multiplier 31. Such memories, complete with A/D and D/A converters are commercially available frame store memories.

Penalty

The foregoing method of correction for luminance non-uniformity may or may not incur a penalty depending upon other factors. The fact that the control signal E_c could be raised, for example, from 0.5 to 1.0 (to correct a dark corner) means that 6 db of gain may be required. This means that the noise inherent in E_c is raised by 6 db. If the camera which generates the RGB signal input to E_c logic 18 has sufficient signal to noise ratio, a 6 db increase in noise may go unnoticed. Even if the noise would go up 6 db, no edge glow would occur. Areas of backing generating an E_c above 1.0 will have a reduced noise level since gain will be reduced to achieve LE_c= 1.0. Since the entire backing will have a constant LE_c of 1.0 volt, it is possible to push the entire LE_c into a very modest clip thus eliminating E_c induced noise. If all of the backing is lighted sufficiently to achieve an E_c at or above 1.0, the there is no penalty for correcting E_c to LE_c.

The circuit of Fig. 3 corrects only for a backing whose luminance is non-uniform. It does not correct for color non-uniformity.

Loading the E_c memory to correct for backing luminance non-uniformity requires the availability of the backing without the subject being present. However, compositing often occurs in post production and the post production facility may have no control over the initial photography (or taping) and likely as not every frame in the scene will include the subject. However, it is still possible to load the memory with an E_c that represents only the backing.

Since E_c is highest in a clear area of the backing and is reduced by any subject matter, and is in fact zero when the subject is opaque, any backing area not occupied by the subject will have a higher E_c than an area occupied by the subject.

If E_c is loaded into memory on the first frame of the scene, the memory will be loaded including the area obscured by the subject, which will be loaded with zeros since E_c is zero in the subject area.

As the scene is run to its end, the E_c values obtained from each frame are examined. The current E_c is compared with the stored E_c and if the current E_c is greater, its value replaces the stored E_c.

In this manner E_c for all areas of the backing that will be visible during the scene have been loaded into memory. Any areas on the backing that are not uncovered by the subject's motion do not need correction since they will never be seen by the camera.

The memory loading method described above may be implemented with the apparatus shown in Fig. 4 E_c logic 18 delivers E_c to switch 45 which, when closed, delivers E_c to OR gate 46. The other input to OR gate 46 is the output of memory 49. Since memory 49 begins with an empty memory, E_c for the first frame is loaded into memory 51. At the end of a frame (two vertical blanking pulses for interleaved video) switch 53 releases switch 45 and closes switch 55 and also switches memory 51 to "read" and memory 49 to "write". E_c for the second frame of video is now compared with the stored E_c from memory 51 in OR gate 57. The larger E_c is stored in memory 49.

The following table illustrates the condition of switches 45 and 55 and memory 49 and memory 51 for odd and even frames.

FRAME	SWITCH 45	SWITCH 55	MEMORY 51	MEMORY 49
1,3,5 etc.	closed	open	write	read
2,4,6 etc.	open	closed	read	write

A sync pulse from sync generator 32 synchronizes the E_c in and out of memories 49 and 51 to be in time with video. The switches 45, 53 and 55 are solid state switches such as Harris HI301. The memories are integrated circuit frame store memories made by a number of manufacturers.

Although two memories are shown to aid in explaining the E_c replacement method, in practice only one memory would be used. The time allotted to each address is divided into two parts, in the first half of the time period the existing E_c is read at the given address for comparison with the E_c from the new frame being examined. If the new E_c is greater, it replaces the data at the given address during the second half of the time period; if smaller, the existing data at the given address is unchanged. After all the frames of video have been examined, the data stored in memory 51 represents the blue field that will be seen by the camera. Having been loaded, memory 51 becomes memory 30 of Fig. 3.

Correction for Backing Color Nonuniformity Using a Single Memory

Assuming a blue backing and a blue floor are used, the color of the backing and floor will appear to have slightly different shades of blue or vary in blue saturation as a function of the angle between the blue surface to the light source and to the camera. Under certain combinations of angles, a diffuse surface reflection of a white light component desaturates the blue color.

If the backing color is uniform, even though the illumination varies from full illumination to full darkness, a specific level of E_c will equal the level of the video signal for each color component, and their subtraction reduces the blue field exactly to zero (i.e., black) simultaneously over the entire backing surface. The percentage of E_c to be subtracted from each colour will be referred to as bias. Fig. 5 shows a circuit (which forms part of the prior art) for implementing this subtraction method for one colour (R, B or G).

Generally, the disclosed method and apparatus cannot operate from the live video which includes the subject because there are no criteria by which one may differentiate between residual floor video and thin white fog, for example. Therefore, correction information is obtained from a memory whose data was generated from the blue set before the subjects are put in place.

An apparatus for implementing color correction is shown in Fig. 6. The scanned field 17, with FG subject removed, delivers RGB video to E_c logic 18. E_c is connected to the positive X input of multiplier 34, Multiplier 34 is configured for unity gain so that when both X and Y inputs are 1 volt, their product is 1 volt. The correction values are stored in memory 40 by the following procedures: set switches 35 and 39 to "MANUAL". In this position, the output of multiplier 34 is the product of E_c and the voltage setting of potentiometer 36. To illustrate, assume E_c = 1 volt, and the blue video from a well illuminated area of the blue backing is .7 volt. Since both multiplier 37 and differential amplifier 38 have differential inputs receiving the same (equal) signal, their outputs are zero. Typically, control 36 is adjusted to result in zero video in the best blue area of the backing. The output of amplifier 38 is the difference between its two differential inputs. This difference is representative of backing non-uniformity and is recorded in memory 40. This means that the blue bias must be increased by the difference voltage in this area of the floor in order to achieve zero video. By first placing switch 39 and then switch 35 in the "RUN" position, memory 40 will deliver the difference voltage to the positive Y input of multiplier 34. When control 36 was previously set to 0.7 volts, the output of multiplier 34 then provides the exact correction needed to achieve zero video output from multiplier 37. By causing amplifier 38 to provide a gain of a little over unity (e.g., 1.5),then control 41 becomes a scaling control so as to achieve exact cancellation of the residual video.

Since the correction comes from memory 40, the correction continues to be applied as a FG subject moves into and occupies a corrected area of the backing. It can be shown that this method also ideally corrects for all levels of transparency of a FG subject.

Fig. 6 illustrates the apparatus needed for the color correction of a single color signal (blue) only. Fig. 7 shows the apparatus required to color correct all three color video signals, as follows: Multipliers 34' and 37' and potentiometer 41' and 36' provide correction for the green video channel. Multipliers 34" and 37" and potentiometers 41" and 36" provide correction for the red video channel. In this embodiment, only one memory 40 and one differential amplifier 38 is used.

The most common source of color non-uniformity is caused by a white diffuse component superimposed over the blue floor's normal blue reflection. While each channel must have its own bias control 36, 36' or 36" and scaling control 41, 41' or 41", the error data supplied by examining one channel (e.g., blue) will provide adequate compensation for floor glare.

One could, of course, employ a memory 40 and switches 35 and 39 for each channel and thus color non-uniformity is independently corrected for each color. Independent correction is required when color deviations differ for each color. Fig. 8 illustrates the use of independent memories. Note that the differential amplifier 38 and scaling potentiometer 41 of Fig. 6 and 7 are omitted in Fig. 8. When using independent memories the residual color error occurring at the output of multipliers 37, 37' and 37" are in each case the exact amount of color error to be corrected for that color. Therefore the gain provided by differential amplifier 38 of Fig. 7 and level adjustments provided by controls 41, 41' and 41" of Fig. 7 are no longer needed.

The use of independent memories as shown in Fig. 8 provides for any range of color deviation and even permits blue set pieces to be painted with blue paint of differing manufacture and differing blue pigments.

The three memories shown in Fig. 8 may be digital random access memories, or a component video tape machine.

One commercial compositing device (sold under the trademark ULTIMATTE), employs a blue clamp such that the blue video cannot exceed the green video. Since in a blue backing, the blue component is always higher than the green component, the blue is always held to the level of the green and is thus equal to green in the backing area. Therefore, in Fig.8, the blue memory is redundant for such a compositing system employing a blue clamp. The correction for the blue video channel may be obtained from the green memory 40' of Fig. 8 with appropriate level control such as control 41" of Fig. 7.

Fig. 8a illustrates a circuit for implementing such embodiment.

A three channel video tape recorder would then satisfy the memory requirements for both luminance correction and full color correction. One tape channel would be used for luminance memory, while the remaining two tape channels would be used for red and green color memories 40 and 40'.

Loading an RGB Backing Memory when the Subject Is In Place

If one is to store the RGB video representing only the backing, then RGB video representing the subject must not be stored in memory. Since E_c is zero for an opaque subject, E_c may be used to inhibit the RGB video in the subject area. Fig. 9 represents the required apparatus. The blue video (shown) enters one input to a multiplier 93. E_c, after being clipped by AND gate 95, is connected to the other multiplier input. When E_c is zero, the multiplier output is zero, thus the output of the multiplier is the video representing the backing only. If this blue video now substitutes for E_c in Fig. 4, then blue video for the backing only is stored in memory. Duplicating the apparatus in Fig. 4 for the red and green video permits all three video signals to be stored in memory.

The memory of Fig. 4 is designed such that as each frame of video is examined, video levels of the current frame, if greater, replace the data in memory.

Thus, the technique of Fig. 4 for loading the memory with backing E_c in the presence of the subject, is also applicable for loading RGB of the backing in the presence of the subject for a moving camera. The AND gate clip circuit of Fig. 9 sets the threshold below which the multiplier operates to inhibit the subject video.

Applicant's existing patents, referenced earlier, pertain to compositing of video signals whether in their primary RGB form or in the form of an encoded signal whereby chroma is encoded as a phase angle of a subcarrier signal superimposed on a luminance (black and white) signal. In the United States, the NTSC standard employs a 3.58 megahertz subcarrier while in Europe the PAL standard employs a 4.43 megahertz subcarrier. Applicant's U.S. Patents US-A-4,409,611 and US-A-4,589,013 describe Encoded Signal Color Image Compositing.

All of the methods described herein which remove variations in backing illumination will do so whether the video is linear or has been gamma processed. Gamma processing is simply the conversion of the linear video signal to the logarithm of that video signal (not necessarily to base 10).

A shadow is sometimes cast upon the backing. If the backing illumination is non-uniform (e.g. if the backing contains a seam or there is any brightness anomaly in the backing illumination) the correction methods described herein will make a complete luminance correction within the shadow while retaining the shadow, when the video signal is linear.

Some video cameras provide, as outputs, both the linear RGB and the gamma processed RGB. Other cameras provide only the processed (log) RGB video. In this case, if one is to fully compensate for non-uniform illumination in the subject's shadow, it is necessary to inversely process (de-log) the video signal; or, where E_c is placed in memory, to de-log E_c.

After correction for backing illumination non-uniformity has been made, the video signals (or E_c) must then be reconverted to log form.

The conversion from linear to log, or log to linear is known in the art and appears in most handbooks dealing with linear integrated circuits, for example, Handbook of Operational Amplifier Circuit Design, Stout & Kaufman. McGraw-Hill, copyright 1976, Chapter 17 Logarithmic Circuits.

Components

The circuits described herein may be implemented using readily available components as follows:

Memories such as 30, 40, 49 and 51 can be implemented by such commercial items as a video tape, video disc, solid state (IC) frame store, and the like.

Amplifiers that compare, provide gain, sum and the like including item 38 can be realized by an operational amplifier such as the Harris HA-2525.

The sync generator 32 is typically a Tektronix Model SPG 170A NTSC sync generator.

Multipliers, for example, 31, 33, 34 and 37 are typically Motorola MC 1495 or MC 1595 four quadrant multipliers.

Divide circuits, for example, 29 can be implemented by configuring the Motorola MC 1595 as a divide circuit as noted in the Motorola Linear Circuits Handbook DL 114.

Clip circuits that provide an upper limit may be implemented by a linear AND gate. Clip circuits that provide a lower limit may be satisfied with a linear OR gate. Circuit diagrams for both gates are shown by Fig. 2 of applicant's U.S. Patent US-A-4,344,085.

Potentiometer controls such as 36 are commercially available from many manufacturers. Values in the range of 1000 to 5000 ohms are most commonly used.

Switches such as 35, 39 may be panel type toggle switches, push button switches or solid state (IC) switches.

Switches such as 45, 53, 55 should be solid state switches such as the Harris HI 301.

Claims

1. An apparatus for use in an electronic compositing system for compositing a foreground video signal and a background video signal, wherein said foreground video signal includes at least a red signal, a blue signal and a green signal and is generated by scanning a colored backing, selectively with or without a subject placed in front of said backing, the system including control means for generating a control signal (E_c) for controlling said compositing, said control signal being derived from said foreground video signal and having a value different from zero where said foreground video signal represents said backing and a value of zero where said foreground video signal represents said subject, the apparatus comprising:

   memory means (30) for storing said control signal (E_c) formed where said subject is not present in front of said backing;
   means (29) coupled to the output of said memory means (30) for determining the reciprocal of the stored control signal;
   first multiplier means (31) for generating a corrected control signal (LE_c) which is the product of said control signal (E_c) formed with said subject present and said reciprocal, such that said corrected control signal (LE_c) becomes unity wherever said foreground video signal represents said backing, and thereby compensates for the effects of variable luminance of said backing on said control signal (E_c).

2. The apparatus defined by claim 1, further comprising second multiplier means (33) for generating an output which is a multiplication of the output of said first multiplier means and said background video signal.

3. The apparatus defined by claim 1, and further comprising a potentiometer (21) for presetting a level, and a limiter (20) which prevents said control signal (E_c) from falling below said preset level so that division by zero by said means (29) for determining the reciprocal is avoided when said control signal is zero.

4. The apparatus defined by claim 1, wherein said memory means (30) comprises:

   a first memory (51);
   a second memory (49);
   a first switch (45) coupled to said control logic means (18);
   a first OR gate (46) having two inputs and an output, one input of said first OR gate coupled to said first switch (45), said first switch for providing said control signal, including said subject, to said first OR gate when said first switch is closed, said first OR gate having a second input coupled to an output of said second memory (49), the output of said first OR gate coupled to an input of said first memory (51);
   a second OR gate (57) having two inputs and an output, one input of said second OR gate coupled to said control logic means, the second input of said second OR gate coupled to the output of said first memory (51); a second switch (55) coupled to said input of said second memory (49) and the output of said second OR gate for providing the output of said second OR gate to said second memory (49) when said second switch is closed;
   control switch means (53) coupled to said first switch and said second switch for alternately opening and closing said first and second switches at the end of each video frame such that said memory is loaded with said control signal representing all areas of said backing not obscured by said subject.

5. A method for removing from a foreground color video signal, nonuniformity of backing luminance of a colored backing, in a scene represented by said video signal selectively including a subject disposed before said colored backing, without affecting the luminance and color of said subject, said video signal including at least a red signal, a blue signal and a green signal, said method comprising the steps of:

   generating a control signal (E_c) for controlling the compositing of said foreground video signal with a background video signal, said control signal being generated from said foreground video signal and having a value different from zero where said foreground video signal represents said backing and a value of zero where said foreground video signal represents said subject;
   characterised by the steps of:
   generating (18) said control signal (E_c) selectively excluding the subject when scanning said colored backing;
   storing said control signal formed excluding said subject in a memory (30);
   taking the reciprocal (29) of said control signal formed excluding said subject;
   generating (31) a corrected control signal (LE_c) which is a multiplication of said control signal including said subject and said reciprocal of said control signal formed excluding said subject, such that the effects on the

control signal of non-uniformities in the luminance of said backing are corrected.

6. The method defined by claim 5 further comprising the step of generating (33) an output which is a multiplication of said corrected control signal (LE_c), by said background video signal.

7. The method defined by claim 5 further comprising the step of limiting (20,21) the minimum level of said control signal prior to taking its reciprocal.

8. An apparatus for use in an electronic compositing system for compositing a foreground video signal and a background video signal, wherein said foreground video signal includes at least a red signal, a blue signal and a green signal generated by scanning a colored backing selectively including a subject present in front of said backing, and said system includes control logic means (18) for generating a control signal (E_c) for controlling the compositing of said foreground and background signals, said control signal being derived from said foreground video signal and having a value different from zero where said foreground video signal represents said backing and a value of zero where said foreground video signal represents said subject, said apparatus comprising:

first multiplier means (34) having an X input coupled to said control logic means (18) and a first Y input coupled to a first adjustable voltage source (36), said first multiplier means for generating an output which is a multiplication of said control signal formed, excluding said subject, by said first adjustable voltage source;
difference means (38) having a predetermined one of said red, blue and green foreground signals, excluding said subject, coupled to a first input of said difference means and the output of said first multiplier means coupled to a second input of said difference means, said difference means for generating a difference signal representing the difference between said first and second inputs of said difference means;
first memory means (40) coupled to said difference means for storing said difference signal;
said first multiplier means (34) having a second Y input selectively coupled to said first memory means, for generating an output which is a multiplication of said control signal formed including said subject and the sum of the signals from said adjustable voltage source and said first memory means, such that when said difference signal becomes zero, non-uniformities in the backing for the color of said predetermined one of said red, blue and green signals are corrected.

9. The apparatus defined by claim 8, further comprising:

first level adjusting means (41) coupled to said first memory means (40) for adjusting the level of the signal output from said first memory means and input to said second Y input of said first multiplier means (34).

10. The apparatus defined by claim 8 further comprising:

second multiplier means (34') having an X input coupled to said control logic means (18), a first Y input coupled to a second adjustable voltage source (36'), and a second Y input selectively coupled to said memory means (40) through a second level adjusting means (41') for adjusting the level of the signal output from said first memory means and input to the second Y input of said second multiplier means, said second multiplier means for generating an output which is a multiplication of said control signal by the sum of said first Y and second Y inputs to said second multiplier means, such that color non-uniformities in the backing for a second one of said red, blue and green signals are corrected;
third multiplier means (34") having a first X input coupled to said control logic means (18), a first Y input coupled to a third adjustable voltage source (36"), and a second Y input selectively coupled to said memory means through a third level adjusting means (41") for adjusting the level of the signal output from said first memory means and input to the second Y input of said third multiplier means, said third multiplier means for generating an output which is a multiplication of said control signal by the sum of said first Y and second Y inputs to said third multiplier means, such that color non-uniformities in the backing for a third one of said red, blue and green signals are corrected.

11. An apparatus for use in an electronic compositing system for compositing a foreground video signal and a background video signal, wherein said foreground video signal includes at least a red signal, a blue signal and a green signal generated by scanning a colored backing selectively including a subject present in front of said backing, and said system includes control logic means (18) for generating a control signal (E_c) for controlling the compositing of said foreground and background signals, said control signal being derived from said foreground video signal, and having a value different from zero where said foreground video signal represents said backing and a value of zero where said foreground video signal represents said subject, said apparatus comprising:

first multiplier means (34) having an X input coupled to said control logic means (18), a first Y input coupled to a first adjustable voltage source (36), and a second Y input selectively coupled to a first memory means (40), said first memory means for storing a difference signal representing the difference between a first one of said foreground color video signals and an output of said first multiplier means formed by a multiplication of said control signal, excluding said subject, and said first adjustable voltage source, said first multiplier means for generating an output which is a multiplication of said control signal by the sum of said first Y and second Y inputs to said second multiplier means, such that color non-uniformities in the backing for said first one of said foreground color video signals are corrected;

second multiplier means (34') having an X input coupled to said control logic means (18), a first Y input coupled to a second adjustable voltage source (36'), and a second Y input selectively coupled to a second memory means (40'), said second memory means for storing a difference signal representing the difference between a second one of said foreground color video signals and an output of said second multiplier means formed by a multiplication of said control signal, excluding said subject, and said second adjustable voltage source, said second multiplier means for generating an output which is a multiplication of said control signal by the sum of said first and second Y inputs to said second multiplier means, such that color non-uniformities in the backing for said second one of said foreground color video signals are connected;

third multiplier means (34") having an X input coupled to said control logic means (18), a first Y input coupled to a third adjustable voltage source (36"), and a second Y input selectively coupled to a third memory means (40"), said third memory means for storing a difference signal representing the difference between a third one of said foreground color video signals and an output of said third multiplier means formed by a multiplication of said control signal, excluding said subject, and said third adjustable voltage source, said third multiplier means for generating an output which is a multiplication of said control signal by the sum of said first Y and second Y inputs to said third multiplier means, such that color non-uniformities in the backing for said third one of said foreground color video signals are corrected.

12. An apparatus for use in an electronic compositing system for compositing a foreground video signal and a background video signal, wherein said foreground video signal includes at least a red signal, a blue signal and a green signal generated by scanning a colored backing selectively including a subject present in front of said backing, and said system includes control logic means (18) for generating a control signal (E_c) for controlling the compositing of said foreground and background signals, said control signal being derived from said foreground video signal and having a value different from zero where said foreground video signal represents said backing and a value of zero where said foreground video signal represents said subject, said apparatus comprising:

first multiplier means (34) having an X input coupled to said control logic means (18), a first Y input coupled to a first adjustable voltage source (36), and a second Y input selectively coupled to a first memory means (40), said first memory means for storing a difference signal representing the difference between a first one of said foreground color video signals and an output of said first multiplier means formed by a multiplication of said control signal, excluding said subject, and said first adjustable voltage source, said first multiplier means for generating an output which is a multiplication of said control signal by the sum of said first Y and second Y inputs to said first multiplier means;

second multiplier means (34') having an X input coupled to said control logic means (18), a first Y input coupled to a second adjustable voltage source (36'), and a second Y input selectively coupled to a second memory means (40'), said second memory means for storing a difference signal representing the difference between a second one of said foreground color video signals and an output of said second multiplier means formed by a multiplication of said control signal, excluding said subject, and said second adjustable voltage source, said second multiplier means for generating an output which is a multiplication of said control signal by the sum of said first and second Y inputs to said second multiplier means;

third multiplier means (34") having an X input coupled to said control logic means (18), a first Y input coupled to a third adjustable voltage source (36"), and a second Y input selectively coupled to said second memory means (40'), said third multiplier means for generating an output which is a multiplication of said control signal by the sum of said first Y and second Y inputs to said third multiplier means;

such that color non-uniformities in the backing for said red, blue and green signals are corrected utilizing said first and second memory means.

13. A method for removing from a foreground color video signal, nonuniformity of backing color from a colored backing, in a scene represented by said video signal selectively including a subject disposed before said colored backing, without affecting the luminance and color of said subject, said video signal including at least a red signal, a blue signal and a green signal, said method comprising the steps of:

generating a control signal for controlling the compositing of said foreground video signal with a background signal, said control signal derived from said foreground video signal and having a value different from zero where said foreground video signal represents said backing and a value of zero where said foreground video signal represents said subject;

characterized by the steps of:

generating (18) said control signal (E_c) selectively excluding the subject;
generating a signal which is a multiplication (34) of said control signal excluding said subject and a first adjustable voltage source (36);
generating (38) a difference signal representing the difference between a predetermined one of said red, blue and green foreground signals, excluding said subject, and said signal which is a multiplication of said control signal formed excluding said subject by said first adjustable voltage source (36);
storing said difference signals in a first memory (40);
generating a corrected control signal for said predetermined one of said red, blue and green foreground signals which is a multiplication (34) of said control signal formed including said subject and the sum of the signals from said first adjustable voltage source (36) and said first memory, such that when said difference signal becomes zero, non-uniformities in the backing for the color of said predetermined one of said red, blue and green signals are corrected.

14. The method defined by claim 13, further comprising the step of adjusting (41) the level of the difference signal output from said first memory prior to the step of generating said corrected control signal.

15. The method defined by claim 14, further comprising the steps of:

providing a second adjustment (41') of the level of the signal output from said first memory for a second predetermined one of said red, blue and green foreground signals;
generating an output which is a multiplication of said control signal by the sum of a second adjustable voltage source (36') and said second level adjusted signal output from said first memory means;
providing a third adjustment (41") of the level of the signal output from said first memory for a third predetermined one of said red, blue and green foreground signals;
generating an output which is a multiplication of said control signal by the sum of a third adjustable voltage source (36") and said third level adjusted signal output from said first memory;
such that when said difference signal becomes zero, color non-uniformities in the backing for said red, blue and green signals are corrected.

16. The method defined by claim 13, further comprising the steps of:

generating a signal which is a multiplication (34') of said control signal excluding said subject and a second adjustable voltage source (36');
generating a second difference signal (37') representing the difference between a second predetermined one of said red, blue and green foreground signals, excluding said subject, and said signal which is a multiplication of said control signal formed excluding said subject by said second adjustable voltage source (36');
storing said second difference signal in a second memory (40');
generating a second corrected control signal (34') for said second predetermined one of said red, blue and green foreground signals which is a multiplication of said control signal formed including said subject and the sum of the signals from said second adjustable voltage source and said second memory;
generating a signal which is a multiplication (34") of said control signal excluding said subject and a third adjustable voltage source (36");
generating a third difference signal (37") representing the difference between a third predetermined one of said red, blue and green foreground signals, excluding said subject, and said signal which is a multiplication of said control signal formed excluding said subject by said third adjustable voltage source (36);
storing said third difference signal in a third memory (40");
generating a third corrected control signal (34") for said third predetermined one of said red, blue and green foreground signals, which is a multiplication of said control signal formed including said subject and the sum of the signals from said third adjustable voltage source and said third memory;
such that color non-uniformities in the backing for said red, blue and green signals are corrected.

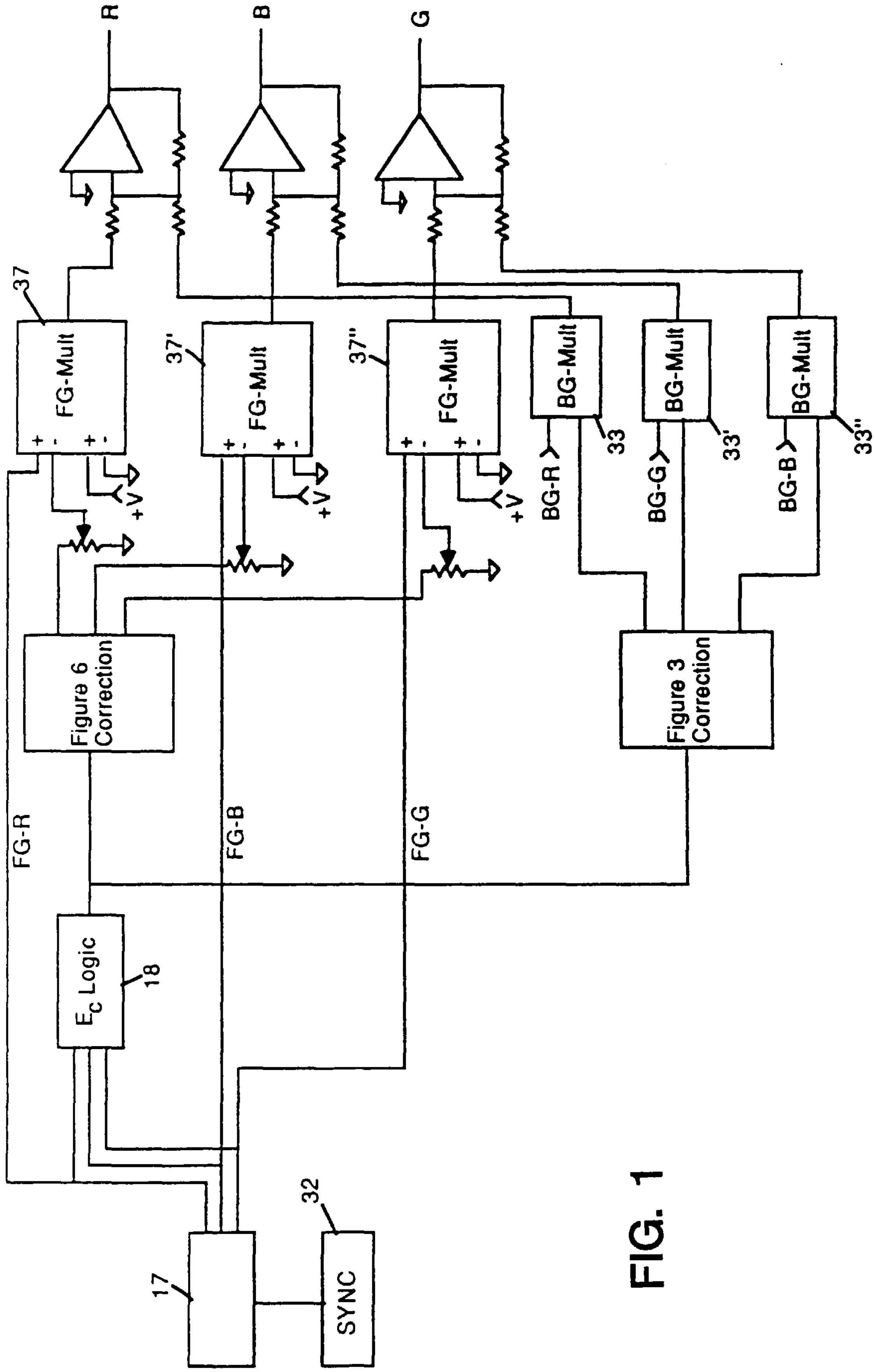

R
B
G
37
37'
37"
FG-Mult
FG-Mult
FG-Mult
BG-Mult
BG-Mult
BG-Mult
33
33'
33"
BG-R
BG-G
BG-B
+V
+V
+V
Figure 6 Correction
Figure 3 Correction
FG-R
FG-B
FG-G
E_C Logic
18
17
32
SYNC

FIG. 1

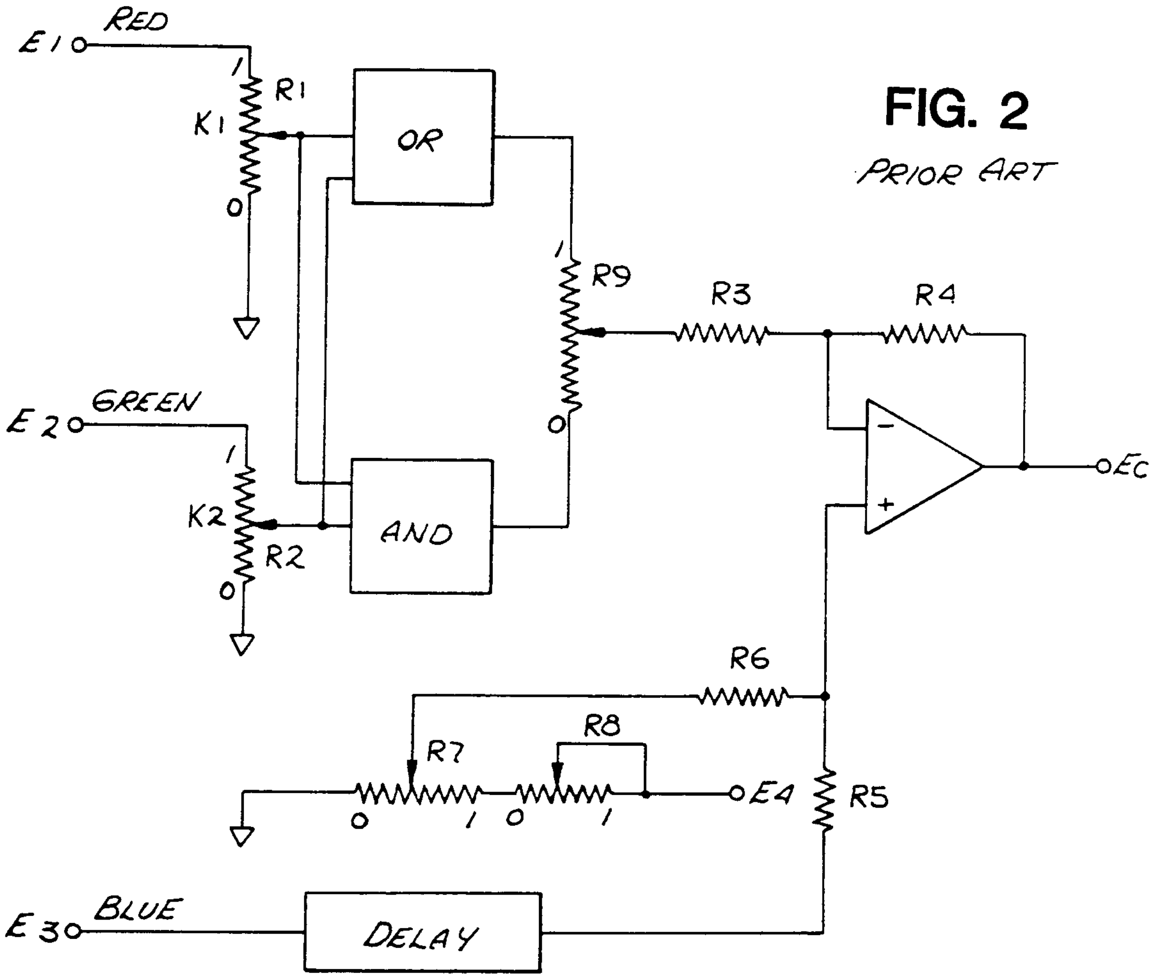


FIG. 2

PRIOR ART

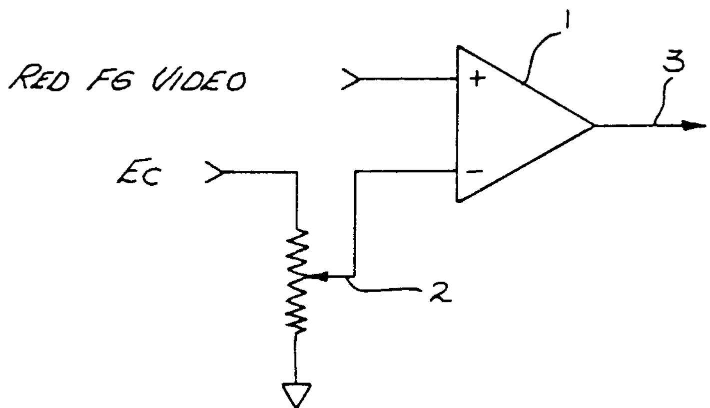
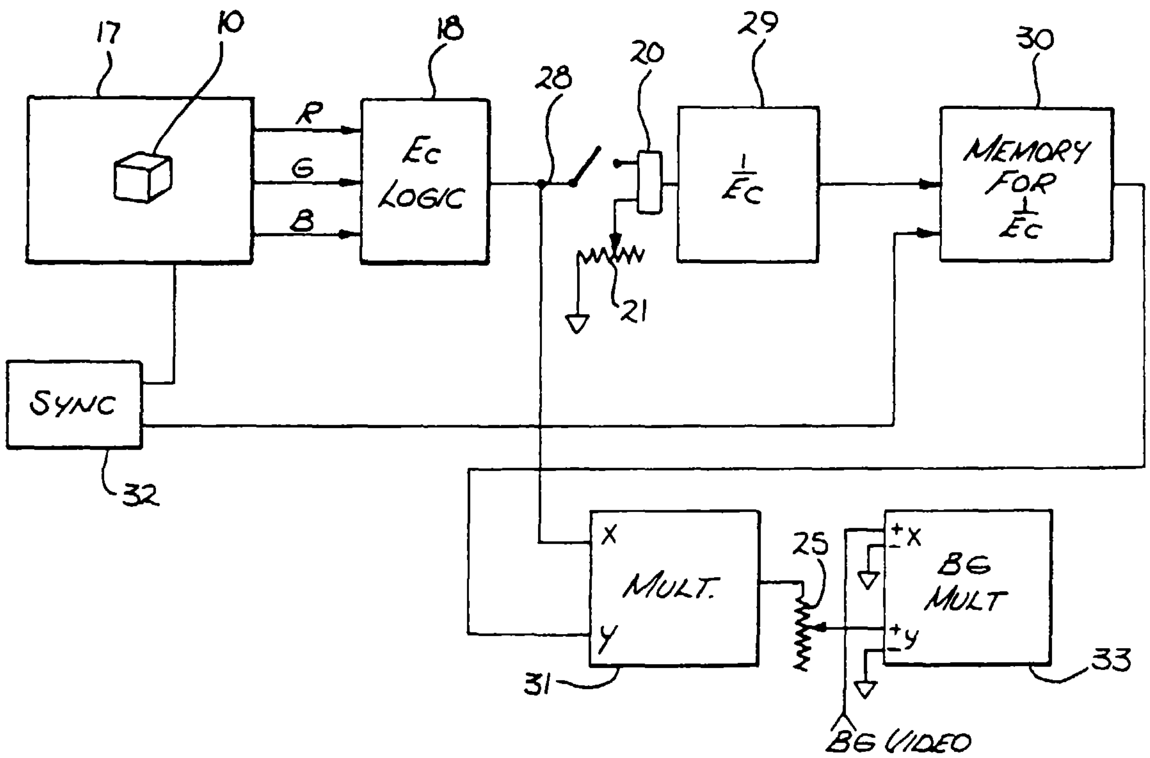


FIG. 5

PRIOR ART

FIG. 3


17
10
18
28
20
29
30
R
G
B
Ec
LOGIC
1
Ec
MEMORY
FOR
1
Ec
21
SYNC
32
X
MULT.
Y
31
25
+X
BG
MULT
+y
33
BG VIDEO

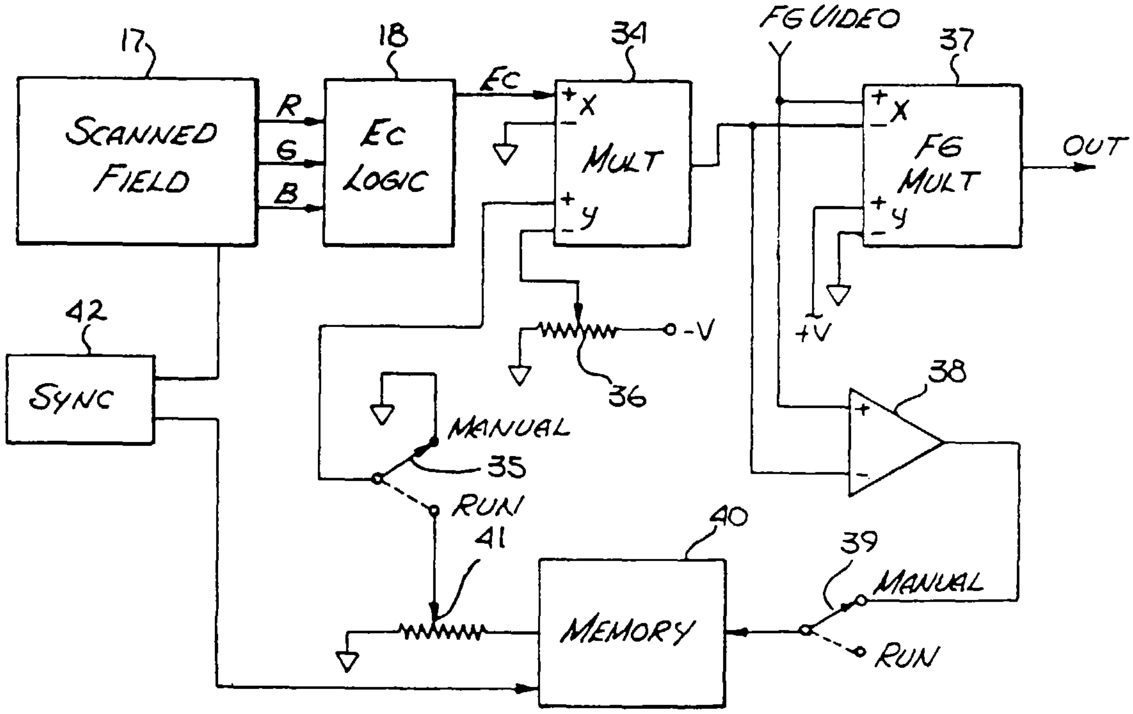

17
18
34
FG VIDEO
37
SCANNED
FIELD
R
G
B
Ec
LOGIC
Ec
+X
MULT
+y
+X
FG
MULT
+y
OUT
+V
42
SYNC
-V
36
38
MANUAL
35
RUN
41
40
39
MANUAL
MEMORY
RUN

FIG. 6

FIG. 4

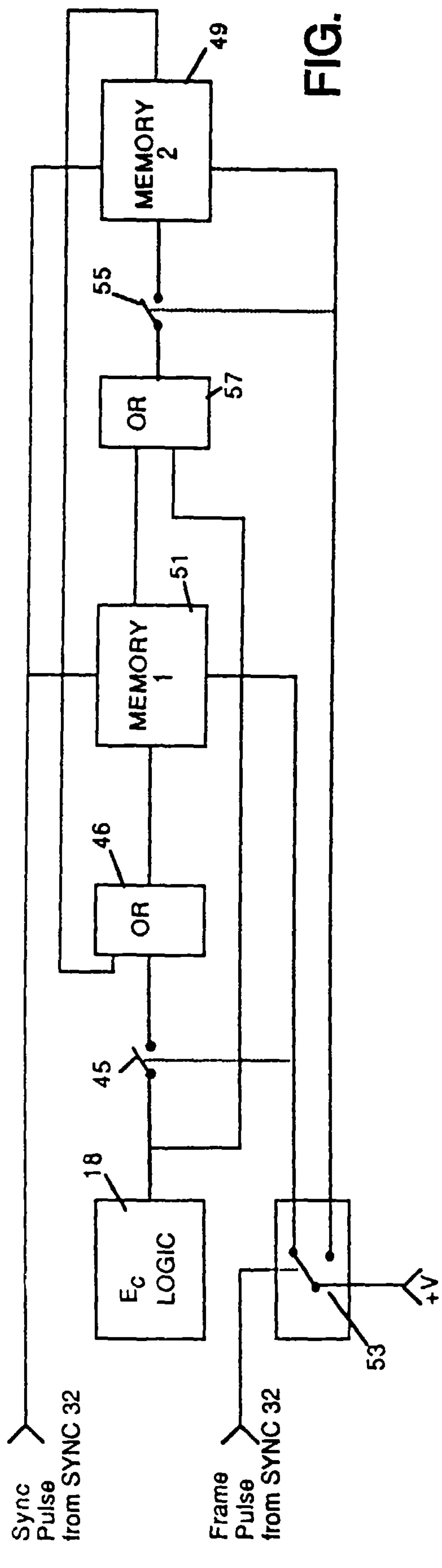
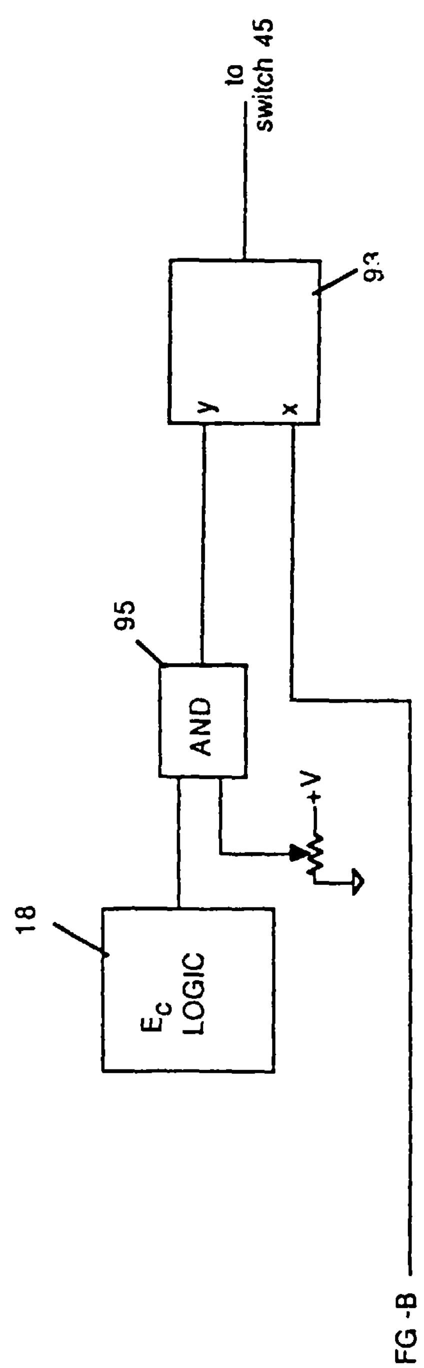
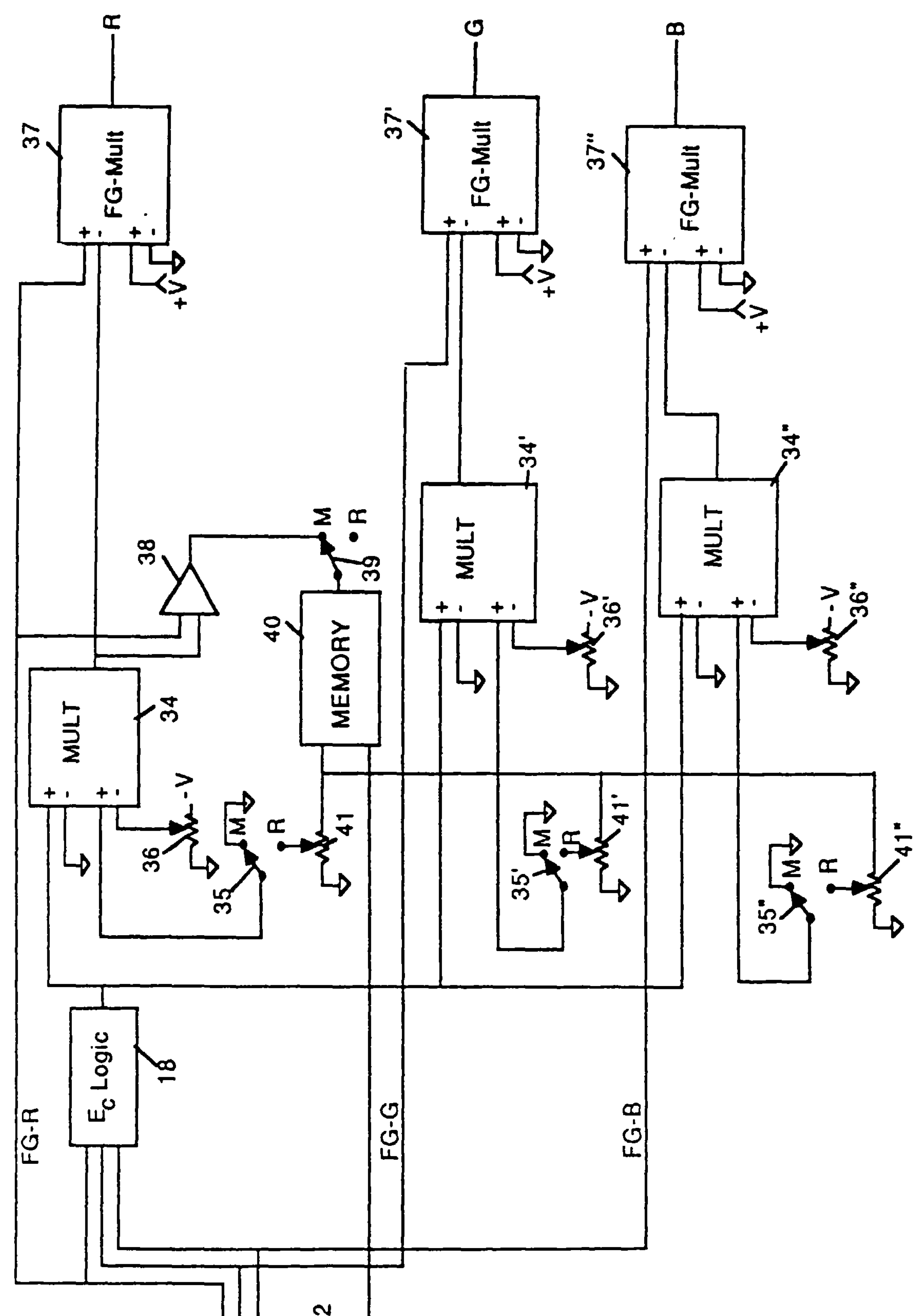

MEMORY
2
49
55
OR
57
MEMORY
1
51
OR
46
45
18
Ec
LOGIC
53
+V
Sync
Pulse
from SYNC 32
Frame
Pulse
from SYNC 32

FIG. 9


to
switch 45
y
x
95
AND
+V
18
Ec
LOGIC
FG -B



R
G
B
37
37'
37"
FG-Mult
FG-Mult
FG-Mult
+V
+V
+V
34
34'
34"
MULT
MULT
MULT
38
M
R
39
40
MEMORY
-V
36
36'
36"
35
35'
35"
41
41'
41"
Ec Logic
18
FG-R
FG-G
FG-B
17
32
SYNC

FIG. 7

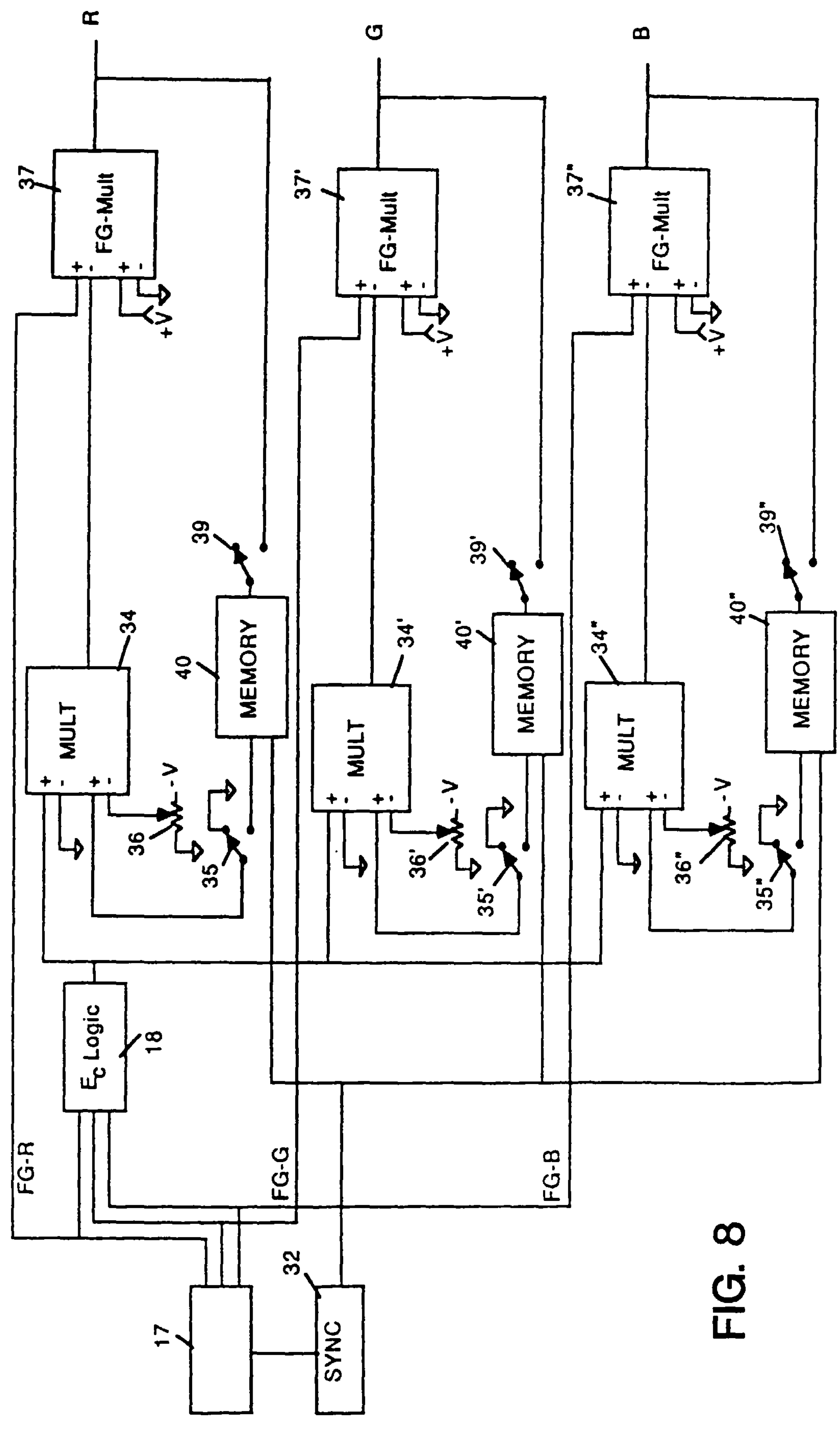

R
G
B
37
37'
37"
FG-Mult
FG-Mult
FG-Mult
+V
+V
+V
39
39'
39"
34
34'
34"
MULT
MULT
MULT
40
40'
40"
MEMORY
MEMORY
MEMORY
-V
-V
-V
36
36'
36"
35
35'
35"
Ec Logic
18
FG-R
FG-G
FG-B
17
32
SYNC

FIG. 8

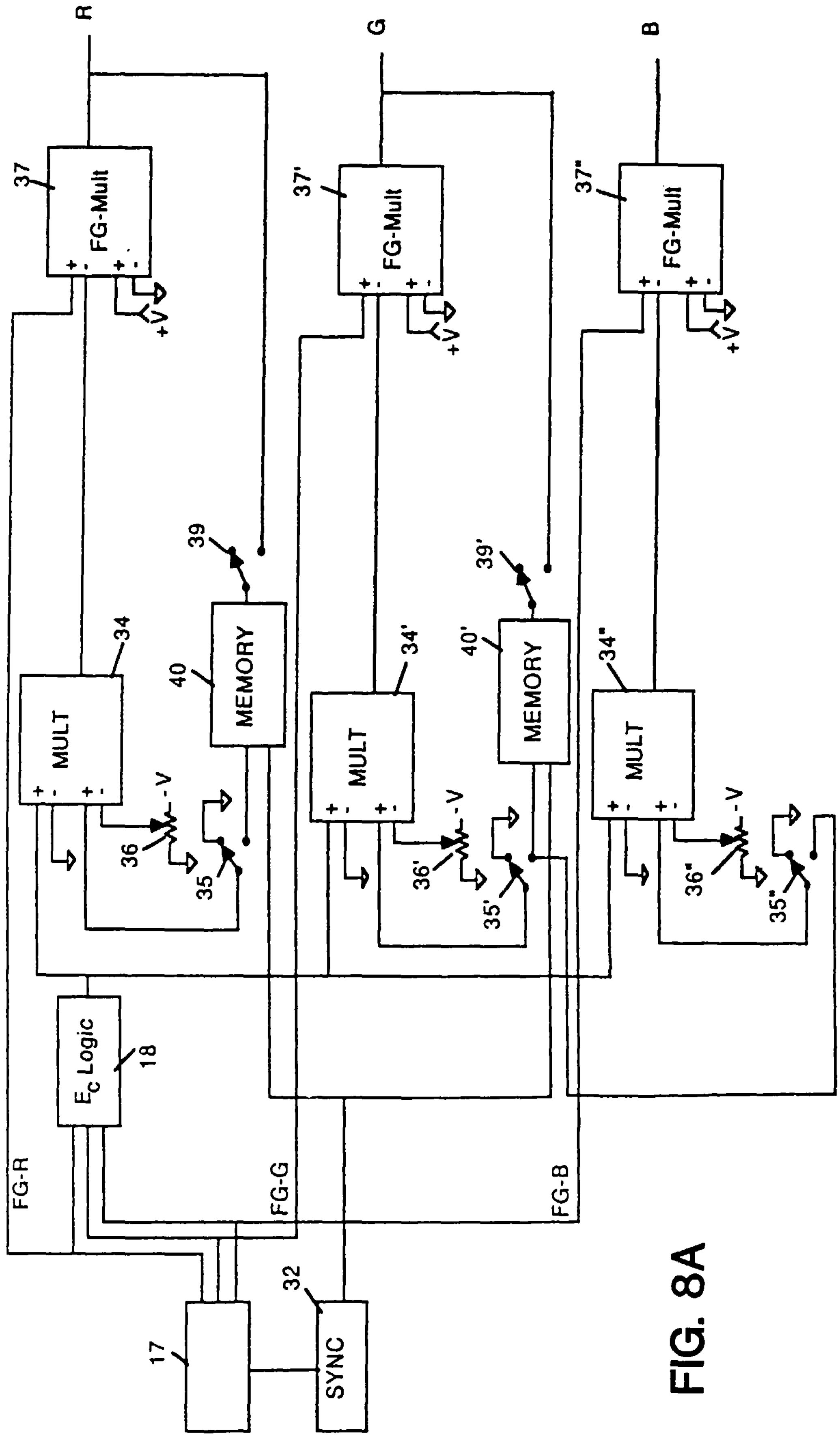

R
G
B
37
37'
37"
FG-Mult
FG-Mult
FG-Mult
+V
+V
+V
39
39'
40
40'
MEMORY
MEMORY
34
34'
34"
MULT
MULT
MULT
-V
-V
-V
36
36'
36"
35
35'
35"
Ec Logic
18
FG-R
FG-G
FG-B
32
17
SYNC

FIG. 8A